To Cross-Layer or Not:
Cross-Layering vs. Strict Layering vs. No Layering

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Strict Layering

Taxonomy:

+ organization of complex communication system
– exceptions are the rule

Abstraction:

+ isolation of network control functions
– interactions obscured

Hierarchy:

+ few interfaces between functions
– complicated interfaces
– processing delays for information exchange

Cross-Layering

Cognizance of behavior of other layers:

+ fosters synergism between control functions
+ reduces redundant functionality
– requires system-wide knowledge

Exchange of information between arbitrary layers:

+ well-informed control decisions
– potentially many interfaces
– stability and robustness of control

Integrated design of multiple layers:

+ tailoring for specific contexts
+ optimization
– loss of generality
– complicated implementation

No Layering

Set of control algorithms:

goals, inputs, and actions
open or closed loop
responsiveness
temporal duration and spatial extent of response
interactions

Retain:

+ modularity
+ well-defined interfaces

Gain:

+ function-oriented view of communications system
+ flexibility of design
+ efficiency and simplicity of implementation

Mobile Ad Hoc and Sensor Networks

Stimuli for cross-layering:

- quality of service (sensor and ad hoc networks)
- security (sensor and ad hoc networks)
- energy (**consumption** primarily for sensor networks, **dispersion** primarily for ad hoc networks)

Challenges:

- channel (sensor and ad hoc networks)
- batteries (sensor networks)
- electronics (sensor networks)

Sensor Networks

Communication and computation trades for controlling energy consumption:

- set of recipients
- schedule for transmissions and sleep/wake cycles
- compression of transmitted information
- fusion of received information

Most effective use of cross-layering for networks of simple sensors is likely to be in network design:

- off-line optimization is reasonable if node trajectories, traffic demands, and environmental conditions are well-known
- but must still be able to deal with unforeseen dynamics

Ad Hoc Networks

Communication, computation, and mobility trades for controlling energy dispersion:

- set of recipients
- schedule of transmissions
- compression of transmitted information
- trajectories of nodes
- frequency
- transmit power
- modulation
- error control coding and retransmissions
- beam width and direction

Most effective use of cross-layering for networks of mobile nodes is likely to be in packet-by-packet adaptation:

- transceivers, antennas, and mobile platforms offer additional dimensions for control
- accurate knowledge of channel is critical

Middleware

Can the use of middleware (as an alternative to cross-layering) help conventional layering adapt to the tactical wireless environment?

Translation:

- convert syntax and semantics of information passed from source layer into form needed by target layer

Information collection and distribution:

- gather information from layers as needed by other layers
- make information available to layers as needed for control

Adaptation:

- add desired control functions to adjacent layers without modifying those layers